Discharge Measurements

USGS
science for a changing world

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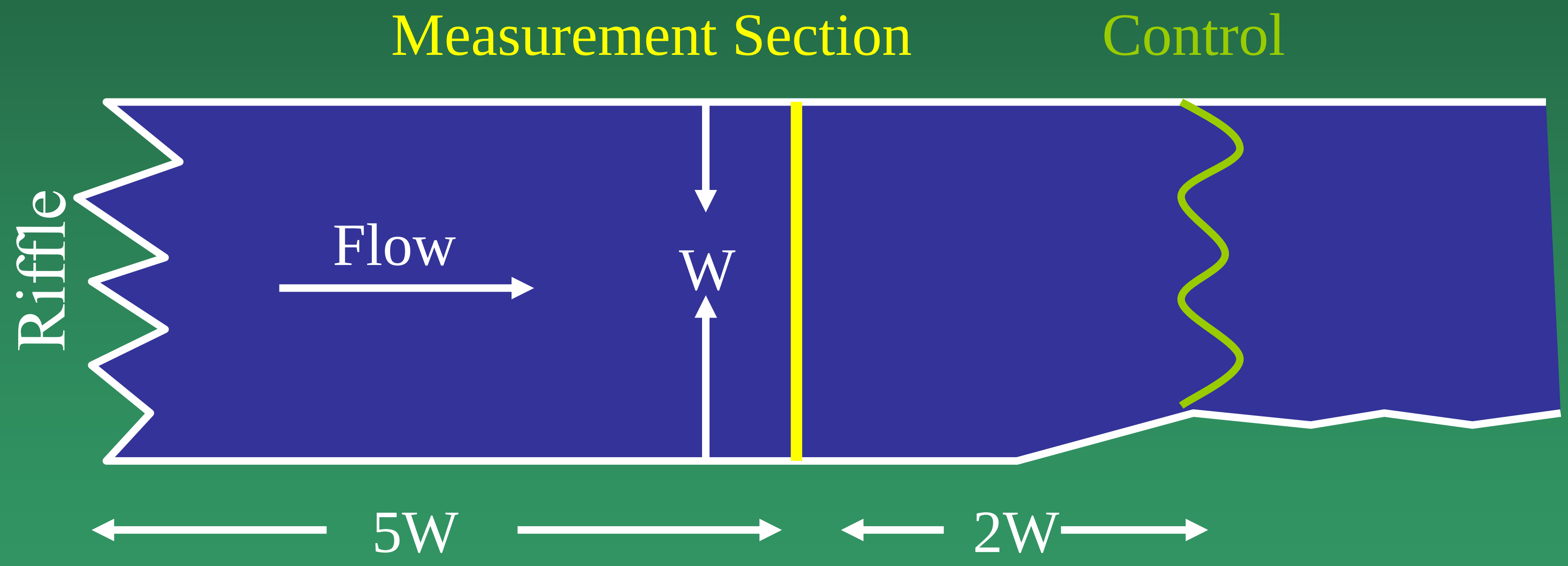
Modified by: Jeff Kitchen, CA WSC

Site Selection

The channel should be straight and uniform for a distance long enough to support uniform flow.



This measuring section at the Snake River near Moran is ideal.

Measuring Discharge

Wading

Bridgeboard

USGS

Measuring Discharge

Ice

Cableway

USGS

THE VELOCITY-AREA METHOD

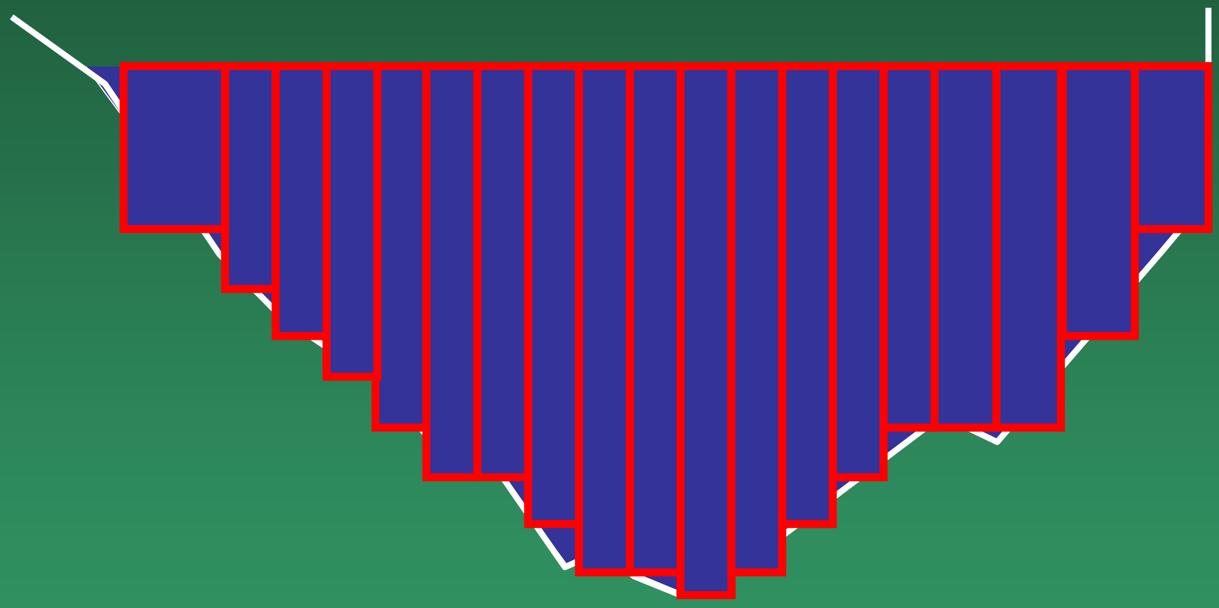
Discharge = (Area of water in cross section) x (Water velocity)

x

Water Velocity

Cross section area

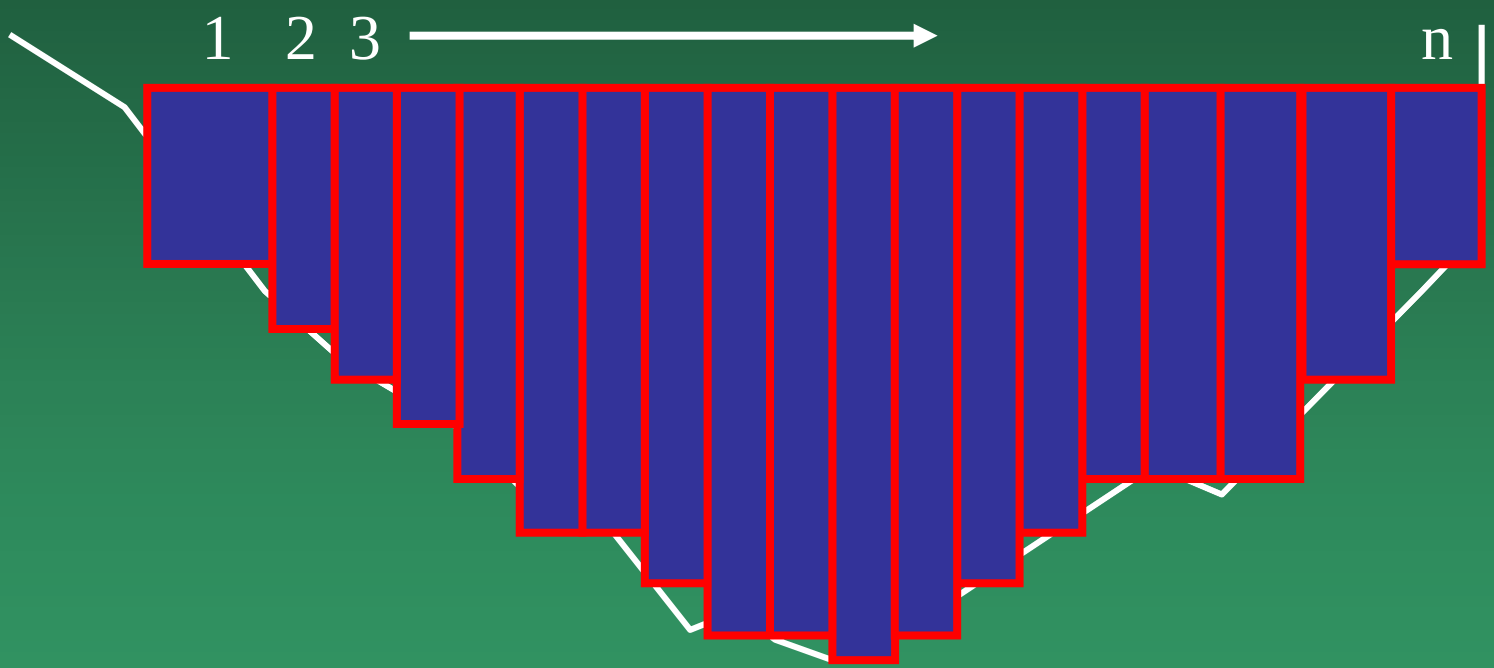
The channel cross section is divided into numerous sub-sections



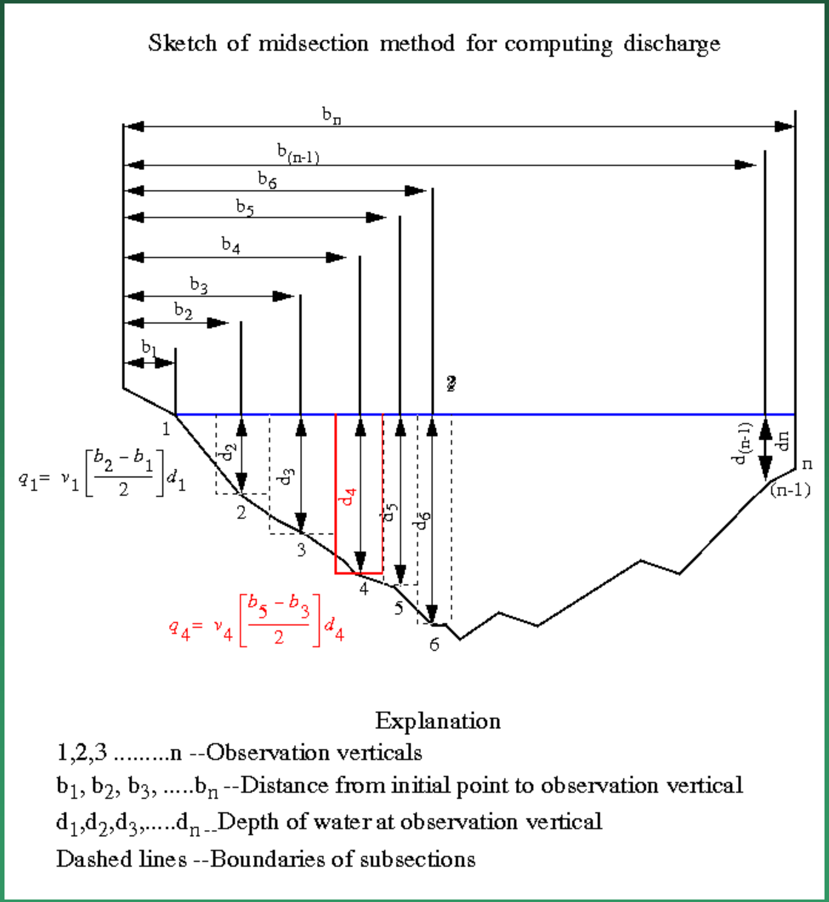
Discharge of each sub-section = Area x Average Water Velocity

The stream discharge is the sum of the discharges in all the sub-sections.

$$\text{Total Discharge} = ((\text{Area}_1 \times \text{Velocity}_1) + (\text{Area}_2 \times \text{Velocity}_2) + \ldots\ldots (\text{Area}_n \times \text{Velocity}_n))$$



Making the Measurement



- Verticals should be spaced so that no sub-section has more than 10% of the total discharge.
- An ideal measurement has no more than 5% of the total discharge in any sub-section.
- Measurements should contain between 25 and 30 sub-sections.
- The spacing between the verticals should be closer in those parts of the cross section with greater depths and velocities.

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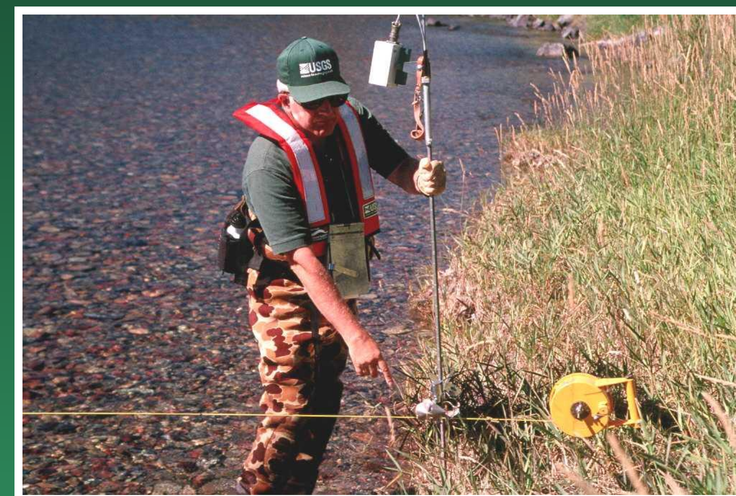
Measuring Cross-Section Area Width



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Measuring Water Depth

- Determine the depth to the nearest 0.02 ft (0.05 ft for turbulent flows).
- Visually extend the water surface to the wading rod mark.

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Measure velocity for at least 40 seconds

- The velocity should be measured for at least 40 seconds
- 40 seconds evens out short-term velocity fluctuations
- 20 seconds is acceptable during periods of rapidly changing stage

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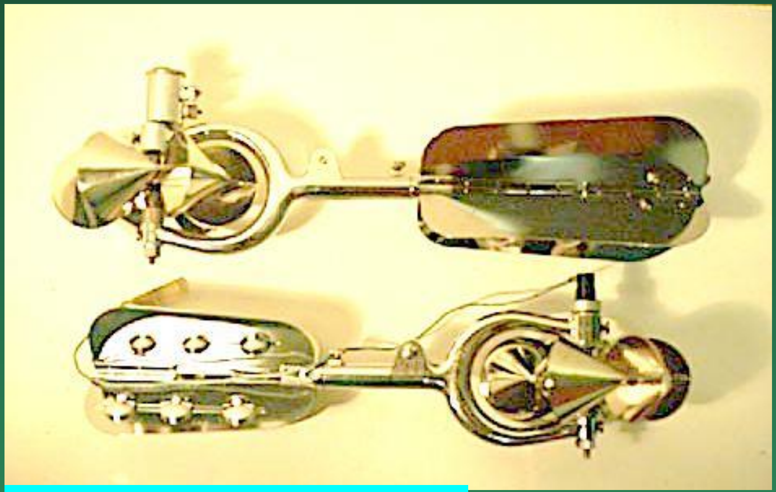
Velocity Determination

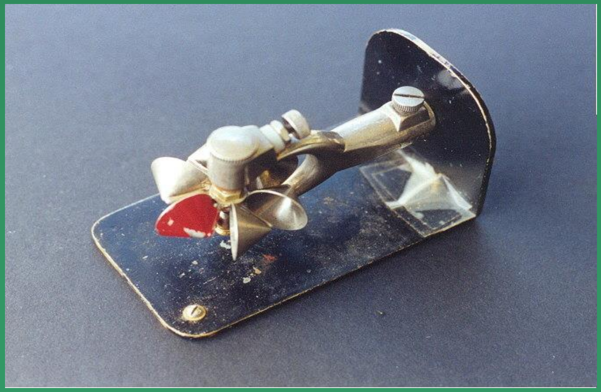


Standard AA Meter

- The USGS generally uses the Price current meter or the FlowTracker
- Use the AA meter for large depths and high velocities
- Use the Pygmy meter for shallow depths and small velocities

See OSW memos 85.07 and 85.14

Pygmy Meter



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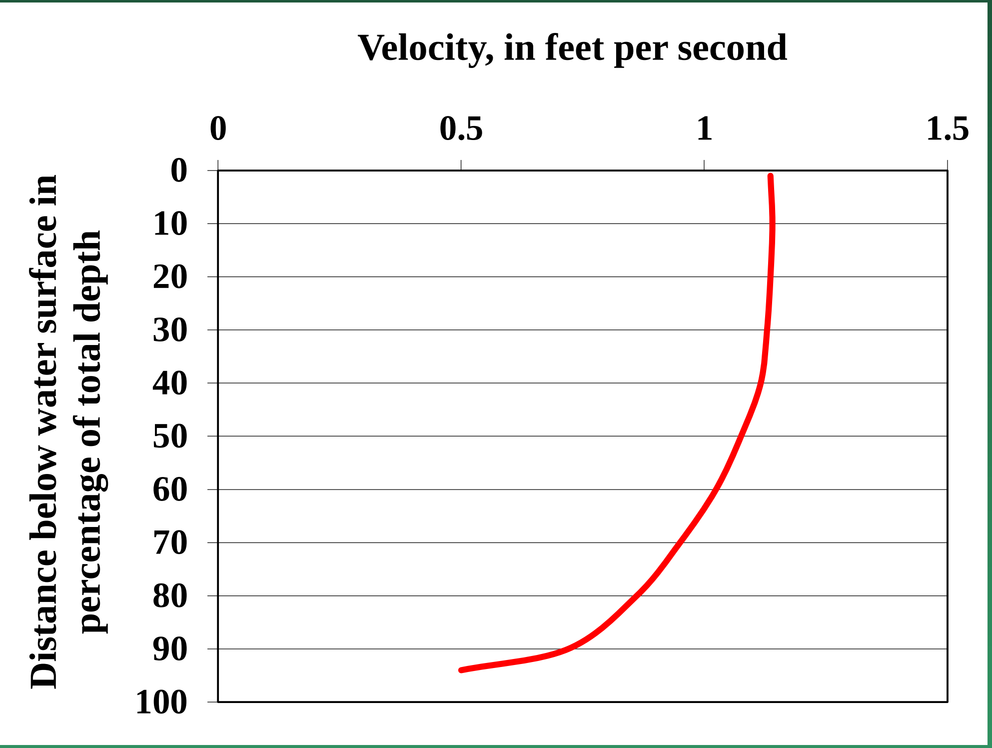
Average Velocity

- The goal is to represent the average velocity in the vertical.
- Measured at 0.6 the depth when depths are shallow.
- Measured at 0.2 and 0.8 the depth when depths are large. These two velocities are averaged to represent the average velocity in the vertical.



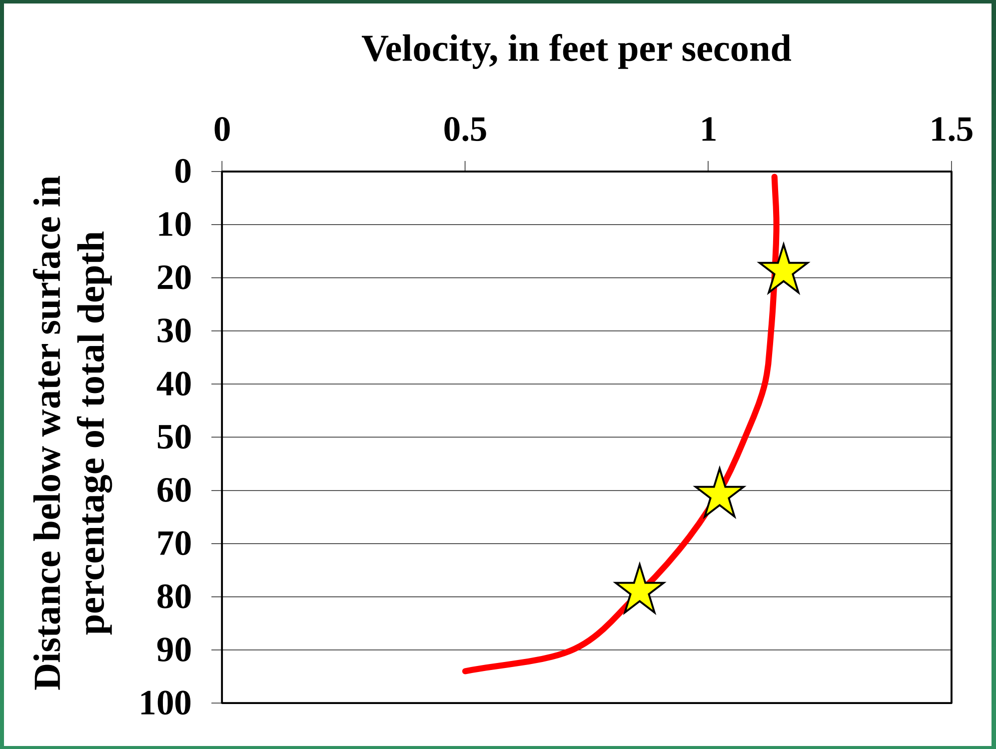
Typical velocity profile

Non-Standard Conditions

- The use of 0.6 and 0.2/0.8 methods assume the velocity profile is logarithmic.
- Velocities should decrease closer to bottom due to friction.
- If the velocity at 0.8 depth is greater than the velocity at 0.2 depth or if the velocity at 0.2 depth is twice the velocity at 0.8 depth then the velocity profile is considered abnormal and the three-point method must be used.

Three-Point Method

- Three-point method is computed by averaging the velocity measured at 0.2 and 0.8 the depth and then averaging that result with the velocity measured at 0.6 the depth.



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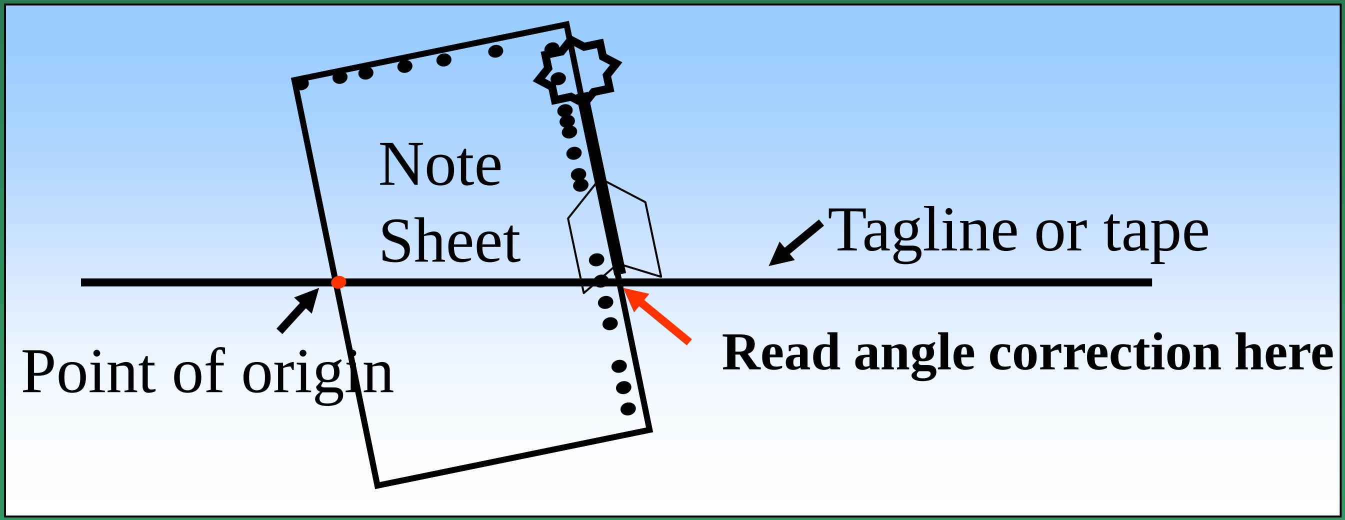
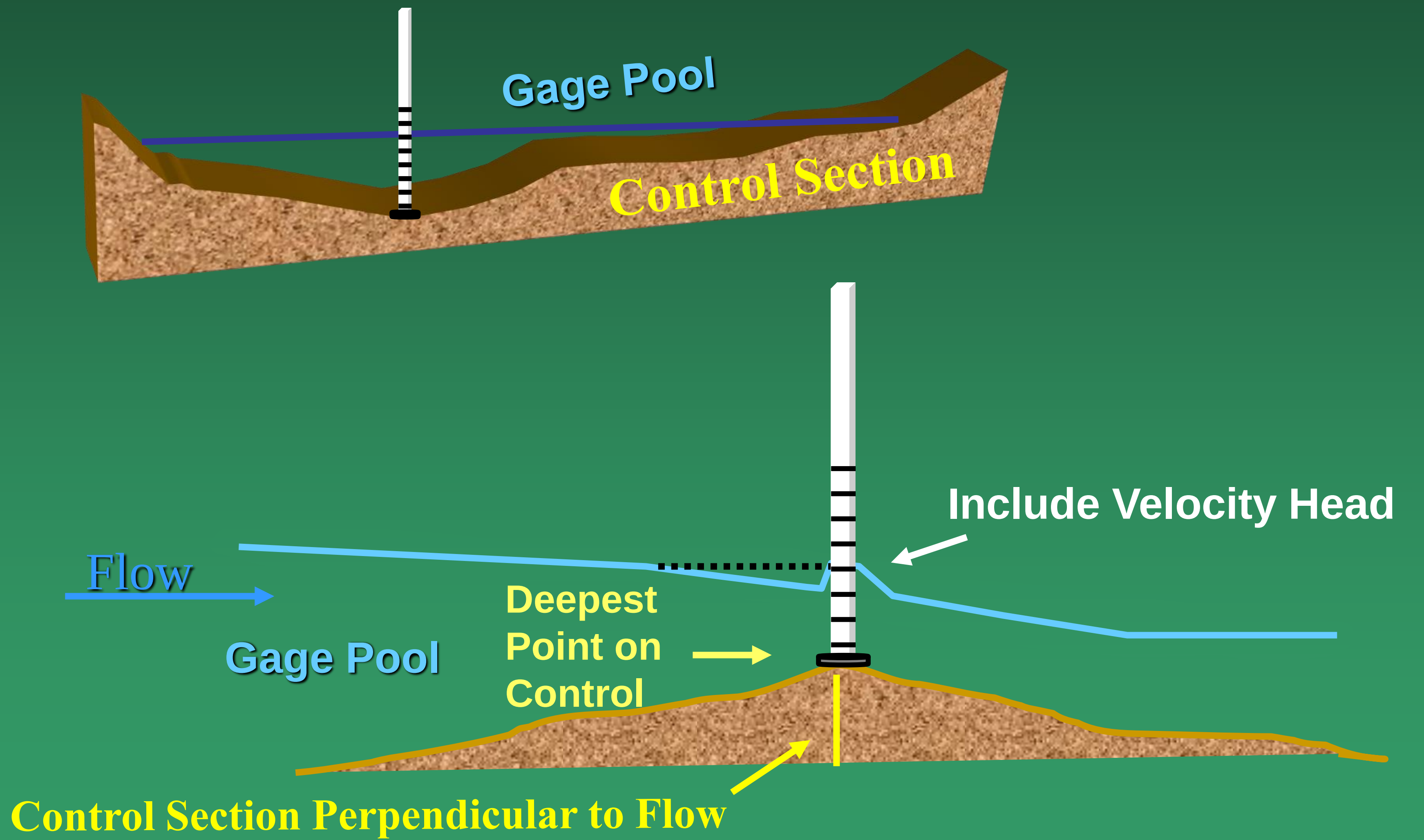
Determining a horizontal angle correction.



Point of Zero Flow



Measuring Discharge with Acoustics

Some Commonly Used ADCP’s

RDI StreamPro

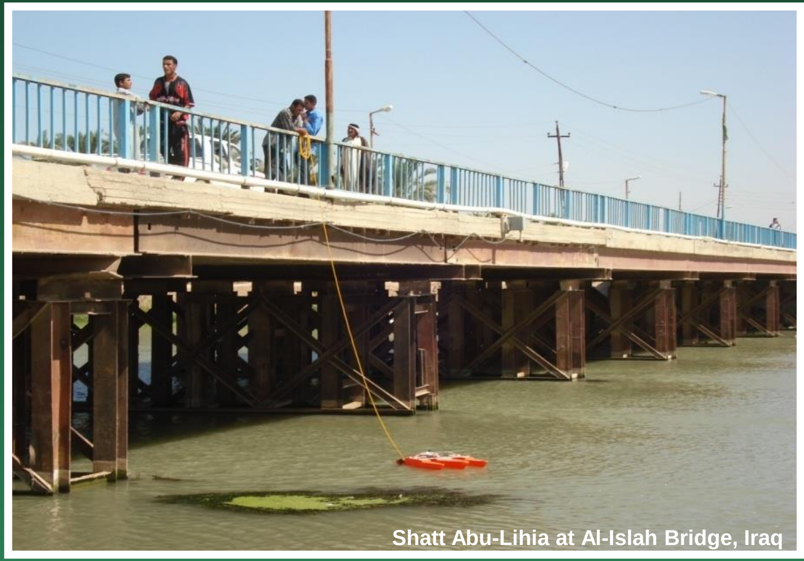
RDI Rio Grande ADCP

SonTek M9

SonTek Mini-ADP

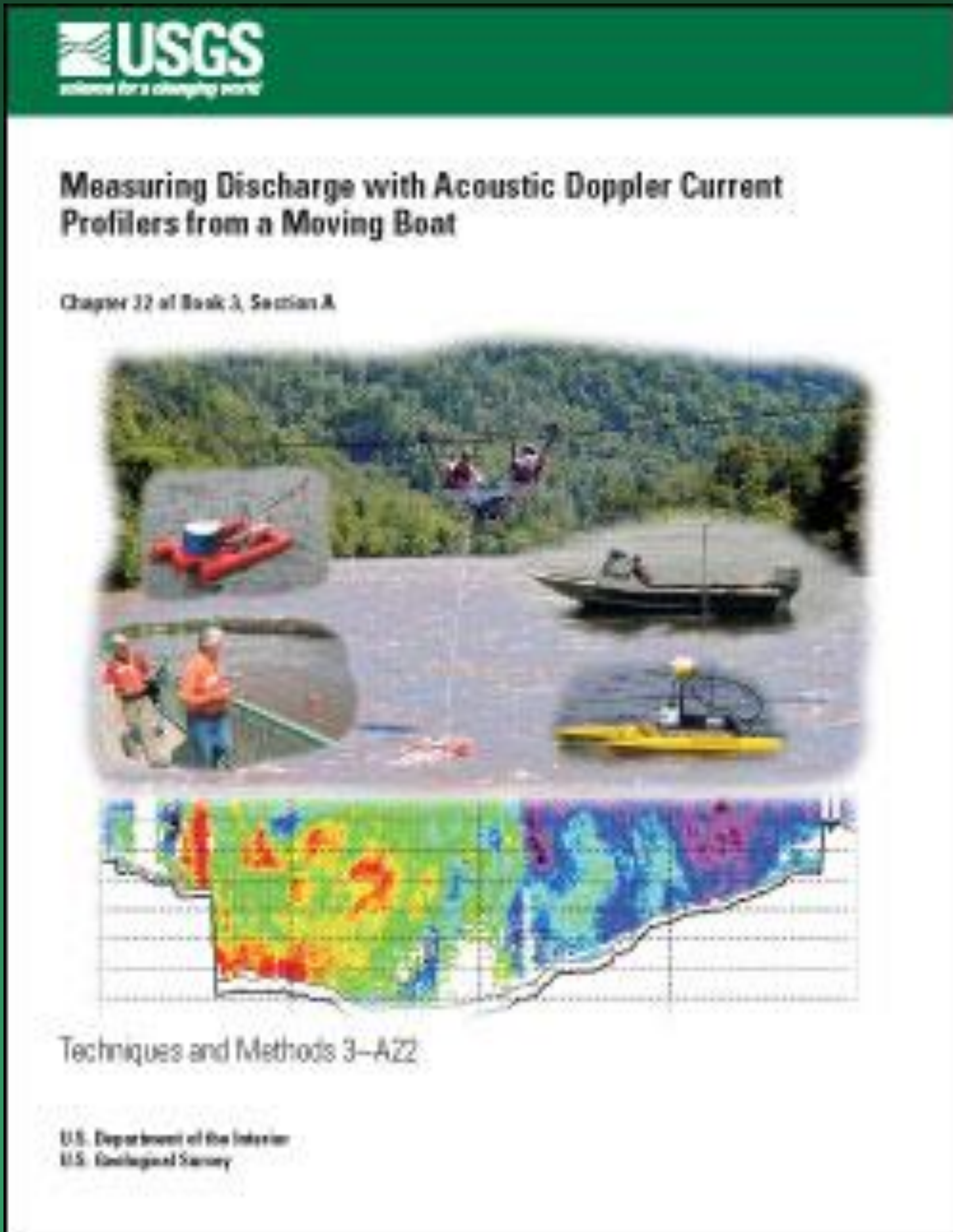
ADCP WITH TETHERED BOAT


Pacific Creek at Moran, WY


Shatt Abu-Lihia at Al-Islah Bridge, Iraq


Snake River near Moran, WY


Henrys Fork near Rexburg, ID

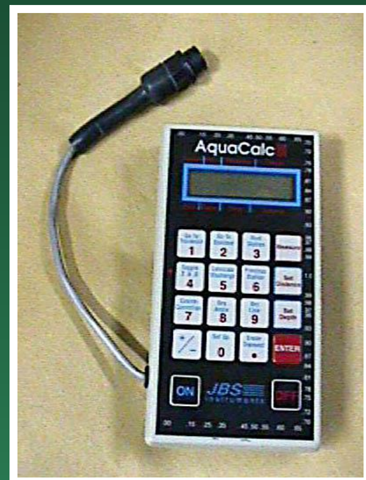


Recent memo points:

- Need for moving bed test
- Need for independent water temperature.
- Recommended 12 minute exposure time.

FlowTracker, Aquacalc and DMX [1]

Aquacalc



Units are now available that compute velocity and/or discharge

FlowTracker

DMX

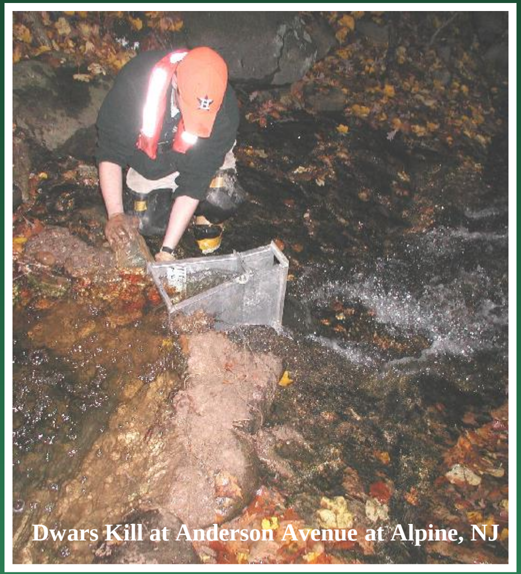
[1]Use of trade, product, or firm names is for descriptive purposes only and does not imply endorsement by the U.S. Government

Benefits of Hydroacoustic Current Meters

- Streamflow measurements are made in a timelier manner
- No moving parts
- Safer measuring conditions
- Measure a higher percentage of the velocities in the stream cross-section
- Ability to measure during rapidly varying flow conditions

Measuring Discharge

Volumetric



Flume

Indirect

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Check Measurements

- Should be made when measured discharge differs by > 5% from rating or shift trend (unless there is an obvious reason for this).
- Ideally should be made using different equipment or at minimum a different cross section.
- Very useful in defining and defending poorly defined segments of the rating.

Other QA considerations

- Spin tests for mechanical meters
- Diagnostic test for ADCPs
- Beam checks for FlowTracker

- Weighted mean GH during periods of rapidly changing stage.

Front Sheet

Summarizes:

1. Measurement results

2. Gage operation

3. Control conditions

Form 9-275F
(Apr. 2001)
ghc=T02[.0080902

U.S. DEPARTMENT OF THE INTERIOR
U.S. Geological Survey
WATER RESOURCES DIVISION
DISCHARGE MEASUREMENT AND GAGE INSPECTION NOTES

Meas. No. 301
Comp. by NDJ
Checked by

Sta. No. 13-0100.65
Sta. Name Snake River at Flagg Ranch, WY
Date Jan. 21, 2009 Party N. Jacobson D. Cole
Width 146 Area 250 Vel. 1.27 G.H. 2.57 Disch. 318
Method .6 .2 .8 No. secs. 27 G.H. change +.01 in 0.7 hrs.
Method coef. 1.0 Horiz. angle coef. 1.0 Susp. rod Tags checked —
Meter Type Price AA Meter No. P-8308268 Meter — ft. above bottom of wt.
Rating used 6-99 Spin test before meas. ✓ ; after ok
Meas. plots -27 % diff. from rating no. # 10 Indicated shift -.34

GAGE READINGS						RP#2
Time		0901	8210		Inside	Outside
0830		2.77	2.77			2.75
0902	reset	2.75	2.75			2.75
0924	Start					
0930			2.75			
0945		Z	2.76			
0958	E					
1000		2.76	2.76			2.76
	Finish					
Weighted MGH			2.75			
GH correction			-.18	due to gage relocation		
Correct MGH			2.57			

Samples collected: water quality, sediment, biological, other

Measurements documented on separate sheets: water quality, aux./base gage, other

Rain gage serviced/calibrated none

Weather: mostly clear, cold
Air Temp. -22 °C at 0830
Water Temp. 0.5 °C at 0830
Check bar/chain found
Changed to at
Correct

Wading, cable, ice, boat, upstr., downstr., side bridge, 600 ft, mi. upstr., downstr. of gage.
Measurement rated excellent (2%), good (5%), fair (8%), poor (> 8%); based on following conditions: Flow: uniform, warm
Cross section: cobble - boulder - gravel - bedrock

Gage operating: running ok Record Removed yes 10K
Battery voltage: 12.2 v Intake/Orifice cleaned/purged: yes
Bubble-gage pressure, psi: Tank 0850, Line 23 ; Bubble-rate 60 /min.
Extreme-GH indicators: max none, min none.
CSG checked: none HWM height on stick — Ref. elev. — HWM elev. —
HWM inside/outside: gel cell = 12.8 charger = 14.3
Control: Floating slush across the channel - minimal shore ice
Remarks: RP#2 = 3.740 - 0.99 = 2.75 (Had to locate under a snow drift!)
GH of zero flow = GH - depth at control = ft., rated
Sheet No. of sheets

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Well documented notes in field allows for better record computations

Discharge Measurement Data

The data acquired during routine discharge measurements are the basis for all computations of streamflow records.

- Snapshots in time documenting observations of real conditions—they display the true stage/discharge relation.
- Data must be thoroughly checked and reviewed.
- The checking process must also be documented on the note sheet.
- Original data can not be erased!

Selected References

- Mueller, D.S., and Wagner, C.R., 2009, Measuring Discharge with Acoustic Doppler Current Profilers from a Moving Boat: USGS Techniques and Methods Book 3, Chapter A22, 72 p.

- Nolan, K.M. and Jacobson, N.D., Surface-water field techniques training class, USGS WRIR 98-4252, (http://wwwrcamnl.wr.usgs.gov/sws/fieldmethods)

- Rantz, S.E., 1982, Measurement and Computation of Streamflow:Volumes I and II, USGS Water Supply Paper 2175, 631 p.

- Turnipseed, D.P., and Sauer, V.B., 2010, Discharge Measurements at Gaging Stations: USGS Techniques and Methods Book 3, Chapter A8, 87 p.

- V.B.Sauer and R.W. Meyer, Determination of Error in Individual Discharge Measurements", USGS Open-file report 92-144